Presentation

To Water Policy Interim Committee
Hydrogeologist Perspective - Water Management
(Mitigation and Aquifer Recharge)

prepared by

NICKLIN

EARTH & WATER, INC.

670 Ferguson Ave, Suite 1
Bozeman, Montana 59718
Phone: 406-582-0413
Email: michaeln@earthandwater.com

July, 2007

Outline of Presentation
Hydrogeologist Perspective
Water Management (Mitigation and Aquifer Recharge)
by
Michael E. Nicklin, PhD, PE

Overview

Several key issues should be considered in order for the beneficial use permitting process to be more meaningful and manageable in consideration of mitigation and aquifer recharge:

I. Water budget analyses at both the project scale and watershed scale should be considered in order to provide a more sound basis for determining when it should be necessary to require mitigation/recharge in the beneficial use permitting process. ***For instance, does a transition from surface water irrigation to ground-water irrigation necessarily lead to negative consequences (adverse impacts to senior water users)?*** [The on-going theme of the DNRC is that it does.].

II. Is it realistic to assume from either a hydrologic or hydrogeologic perspective that mitigation or aquifer recharge will be viable solution for most or all situations? ***In other words, can a one shoe fits all approach be applied to natural systems that are in a majority of instances highly complex?*** [This is a presumption of the current legislation as defined in HB 831].

III. **How can we make the process more manageable?** The DNRC needs to consider the intent of the legislators and also needs to clarify its policy as to when mitigation or aquifer recharge is required. Clearer articulation or developing of language that defines what constitutes an adverse impact is desirable.

Transitions in Water Use Practices

1. Water management considerations for decision making (Transitions in water use):

   - Project scale - local significance (i.e., a proposed ranch irrigation well, proposed subdivision, etc.)
   - Watershed scale - collective significance (i.e., Gallatin Valley).

   [Attachment A].

2. Key questions that should be addressed as part of the water balance analysis:

   - Quantify consumptive use (evaporation and evapotranspiration) before and after.

[Attachment B]

- Again, let us consider conditions at the following two levels:

  - Neighborhood or project scale
  - Watershed scale

  Pictorial on this (compare agriculture versus a subdivision) [refer back to ***Attachment B***].

- How do we accomplish these? Simply compare what happened before with what happened afterward by adding and subtracting or completing "water budgets".

  - Quantify the amount of evapotranspiration before and after for the given parcel of land.

  - In the event the land had been irrigated before, a comparison should be made to determine if there is a net increase or decrease in evapotranspiration.

  - If the overall consumptive use is projected to decrease for that given parcel, isn't it logical to conclude that the overall changes will not lead to adverse impacts? In this instance, why should mitigation or aquifer recharge be required?

  *Cameron Springs example [**Attachment C**]*

  Annual consumptive use before with surface water irrigation (alfalfa) was 37 million gallons.

  Consumptive use with the proposed development is projected to be 12.4 millions gallons.

  Hence, with the proposed land use transition, there would be a net reduction in water consumption (water lost to atmosphere) of about 25 million gallons. Yet, based upon my recent experiences with DNRC, the starting point would be to require mitigation to offset "impacts" caused by keeping the 12.4 million gallons used by lawns.

<u>"In the event the revised land use will lead to reduced evapotranspiration for that given parcel of land, is it appropriate to require either surface water mitigation or aquifer recharge?"</u>

Furthermore, careful scrutiny of the above accounting procedure for the above example is that requiring aquifer mitigation or aquifer recharge is a form of "double counting."

<u>*Gallatin Valley example [**Attachment D**]*</u>

It is key to note that simply placing/using wells does not necessarily translate into increased evapotranspiration at the local or at the watershed scale. The so-called "cumulative impacts of wells" argument (prevalent language we hear in the Gallatin Valley) is not being borne out when the data are evaluated at either the watershed or subwatershed scale. Any changes in stream flows that are observed in the last several years is mainly attributable to drought.

In fact, although not part of my presentation today, I am currently developing a valley-wide simulation effort which will test the viability of conjunctively managing surface water and ground water in the Gallatin Valley. I believe that if we manage the system properly we can actually devise means which will benefit all the users of ground water and surface water in the Gallatin Valley, including those who desire instream flows. Similar efforts should be viable elsewhere in the state of Montana as well.

<u>Viability of Mitigation and Aquifer Recharge</u>

Just how often will either mitigation or aquifer recharge be feasible for a given hydrologic/geologic setting? Keep in mind the following:

- <u>*There are significant geologic limitations (for aquifer recharge)*</u>

  Requires ideal hydrogeologic conditions. Not very often are they ideal.

  See ***Attachment E.***

- <u>*Example where it will work*</u>

  <u>Ideal setting (Four Corners Area, west of Bozeman, MT)</u>

- *<u>Example where it is infeasible (will not work)</u>*

  Big Sky and many other areas of Montana (***Attachment E***).

  <u>Other Physical Limitations</u>

  Water availability
  Land availability

2. What are we really accomplishing in consideration of the observations in the Gallatin Valley where there is little evidence of the so-called cumulative impacts of ground-water development on the existing aquifer systems nor is there any evidence that it has impacted streams. See ***Attachment D***.

<u>How Can We Improve the Process?</u>

1. An overall watershed (or subwatershed) water budget analysis should be performed that will consider the collective impacts or lack thereof of water use transitions that may are occurring or which are projected to occur in a given watershed. This will allow some perspective to be made when predictions are being made regarding implications in water use changes.

2. An overall project scale water balance analysis should be made at the local scale to determine if there is a basis to believe there may be adverse impacts. Consideration is appropriate to determine what occurs naturally (with or without development or irrigation). For instance, if the analysis shows that less water will be consumed, just what is the general logic of requiring mitigation or aquifer recharge?

3. Determine if it is really necessary to impose globally sweeping requirements such as mitigation and aquifer recharge. Clearly, in the case of the Gallatin Valley, such burdensome requirements are unnecessary (see ***Attachment D***). In effect, it is my opinion that the existing transitions in water use from surface water to ground-water is "self-mitigating" in a many, if not a majority, of situations.

4. It is recommended that DNRC more clearly articulate the conditions that must exist for it is necessary to implement either mitigation or aquifer recharge. For instance, the following are questions that require answers:

   - If a land use change leads to a reduction in consumptive use why would it be necessary to implement either aquifer recharge or mitigation?

- If a land use change leads to an increase in consumptive use, yet the change is immeasurably small, will DNRC require mitigation?

- What is DNRC's recommendation if mitigation or aquifer recharge are both infeasible (as in the case of Big Sky)?

Attachment F provides my resume to demonstrate the nature of my 30 plus years of ground-water and surface water related experiences in government, academics and in the private sector.

Attachment A - Plate 1

Example of a Local Scale
(project level)
Study Area

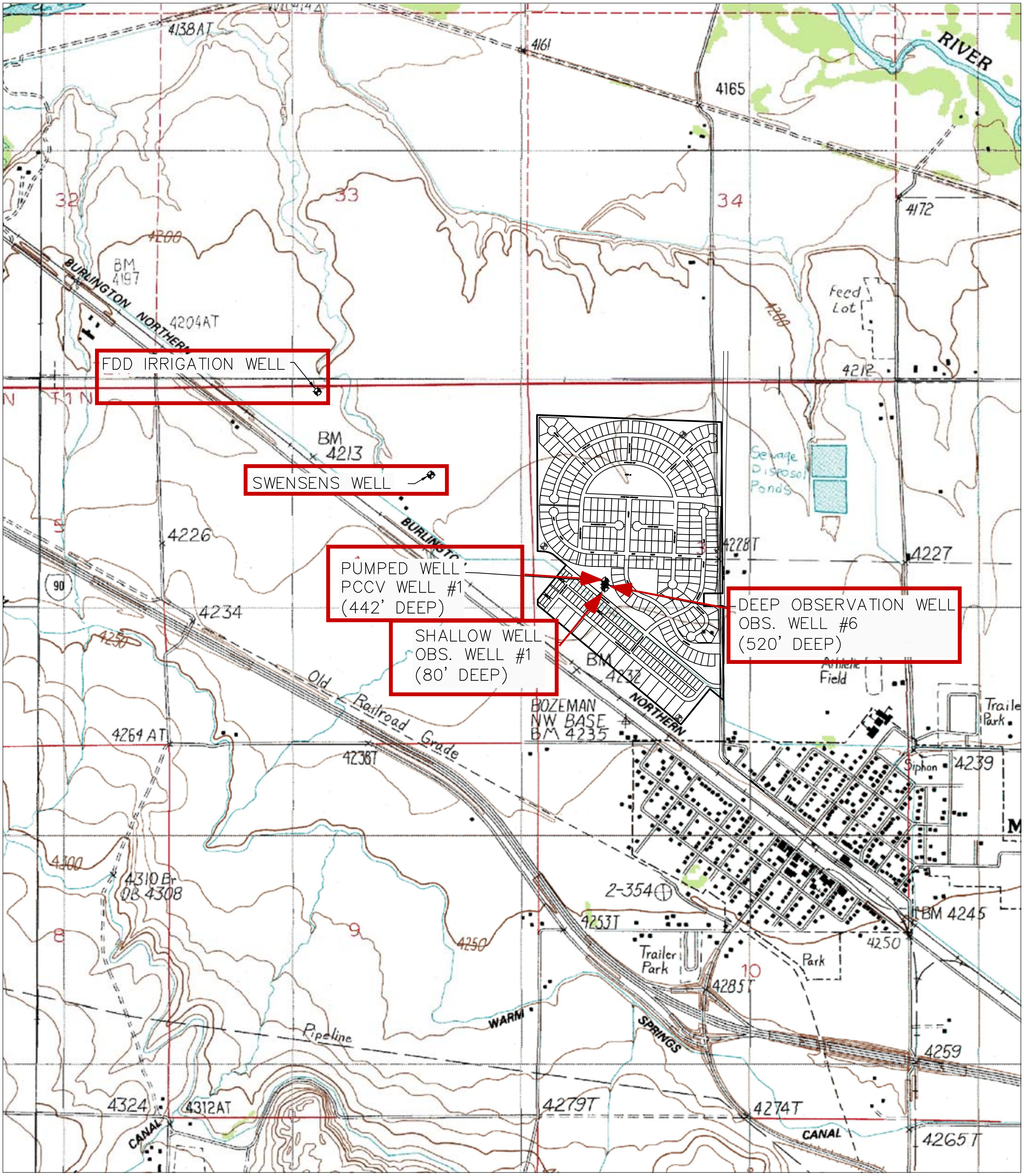
VICINITY MAP OF PIONEER CROSSING & CENTENNIAL VILLAGE AQUIFER TEST PROGRAM 6/22/2007

LEGEND

WELLS SELECTED FOR MONITORING DURING 48 HR AQUIFER TEST

N

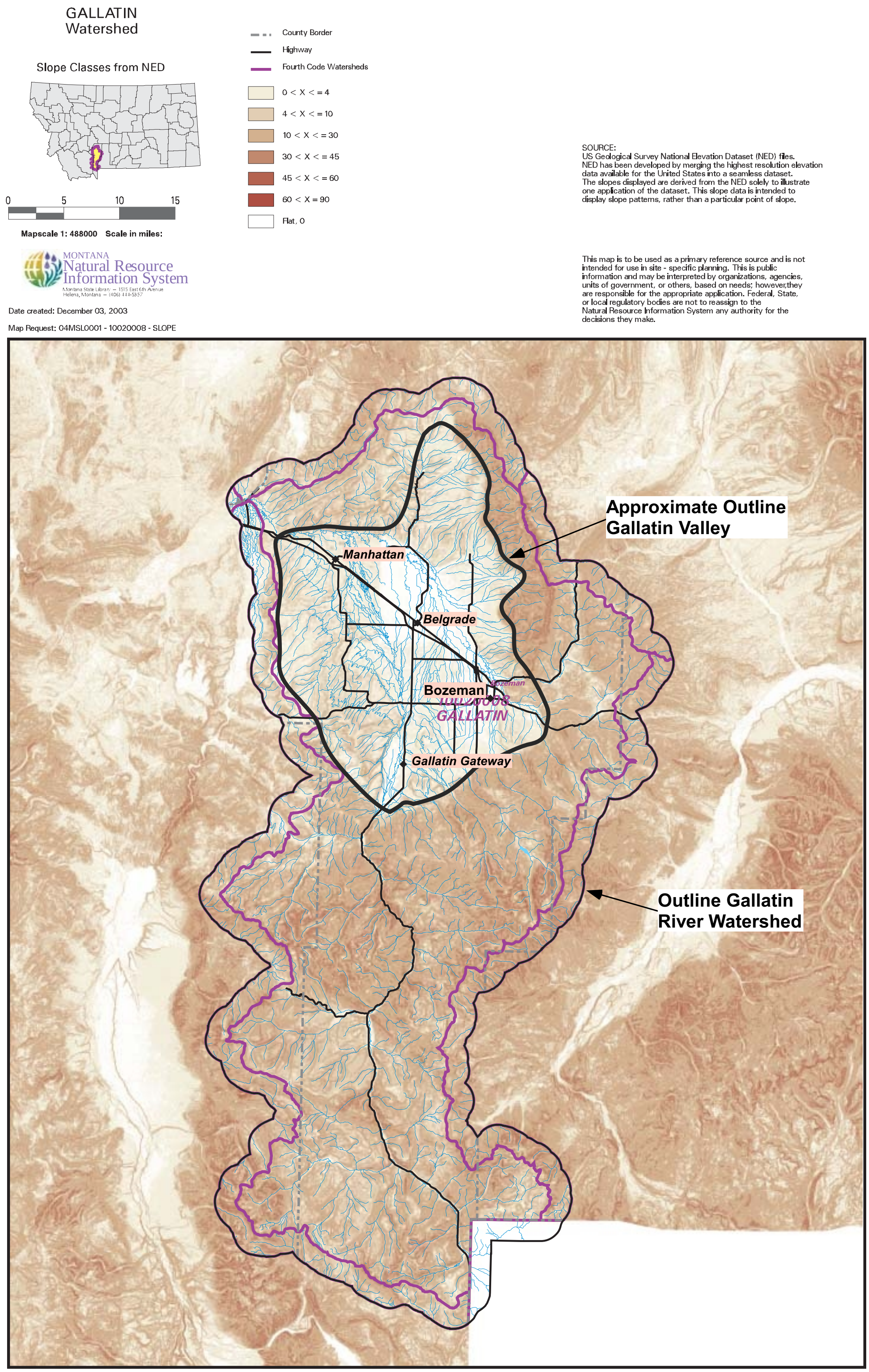
2000 feet



Z:\Land Projects\03-536\dwg\Gallatin County.dwg 6/22/2007 9:14:10 AM MDT

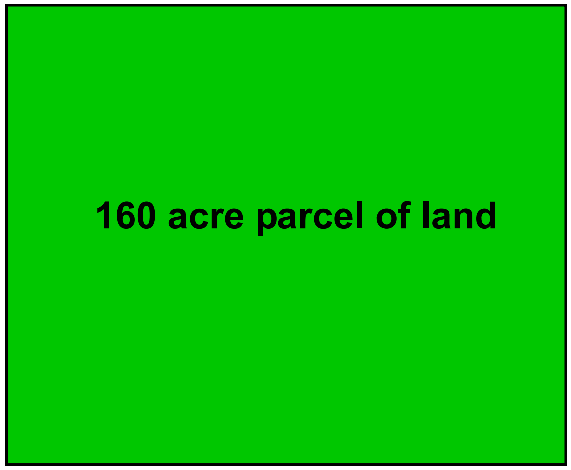
Attachment A - Plate 2

Example of Watershed (or Subwatershed) Scale Study Area

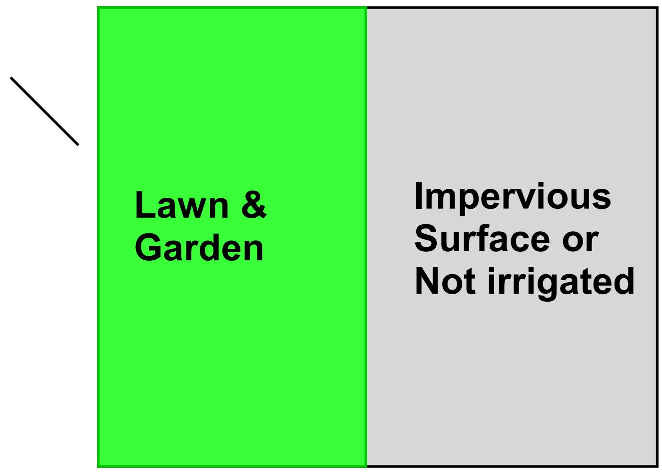


January 4, 2007 c:\leg\gr\report\fig_02 Issued for Doney Law Firm	NICKLIN EARTH & WATER, INC.	**Gallatin River Watershed** **Montana Natural Resource Information System**	**Figure 2**

Attachment B
(conceptual illustration - selected land use conditions)



Agriculture Irrigated
(Alfalfa)
[more water consumption]



1. Subdivision - lawn/Garden.
50 % of land either not irrigated or impervious.
Consumption substantially less than irrigated agriculture

2. Net consumption at a subdivision compared to native land may be more or less than what occurred on native land (depends on annual precipitation and water balance analysis).

Native Land
(water consumption will vary depending upon the local precipitation)

See Table 1 Attached on next page for typical consumptive rates - Gallatin Valley

Table 1

Crops and Turf - Gallatin Valley
Based upon Belgrade Climate Conditions

Type Cover	ET Value inches	Effective Precipitation, in	Irrigation Portion In	ac-ft/acre
Agricultural Crops				
Irrigated Alfalfa (average of Bozeman, Belgrade)	22.45	5.54	16.91	1.41
Irrigated Spring Grain (average of Bozeman, Belgrade)	16.90	5.54	11.36	0.95
50 % of Each Crop	19.68	5.54	14.14	1.18
Development				
Irrigated Turf or Pasture Grass *	20.28	5.54	14.74	1.23

Note: both effective precipitation and ET values are based upon the average of Bozeman and Belgrade values. See Attachment A for further details.

* A relatively higher effective precipitation of 8.85 inches (average of 10.6 for MSU and 7.1 for Belgrade) for turf could have been employed. The use of 5.54 inches is deemed to be very conservative for estimating consumptive use for turf.

Attachment C

Design Report of the Cameron Springs Subdivision

Design Report for the Cameron Springs Subdivision
NW ¼ Section 19, T1S, R5E Gallatin County Montana
March, 2007

Water Usage History

The area proposed for the Cameron Springs Subdivision is roughly a quarter section (160 acres) of ground that was used to grow either alfalfa hay or grain crops. A center pivot provided irrigation to the crops grown for the last several years. According to the property deed, about 325 miner's inches of irrigation water from the Spain Ferris Ditch Company has traditionally been used to supply the pivot's irrigation water. This irrigation water has the following priority dates and relative volumes:

Water right 41H 15819 00	June 20, 1890	69.1 cfs
Water right 41H 15821 00	January 30, 1886	30 cfs
Water right 41H 15820 00	June 1, 1892	7.5 cfs

These water rights are part of the water rights owned by the Spain Ferris Ditch Company. One share in the Ditch Company is equivalent to one inch of water and 40 miner's inches of water is equivalent to 449 gpm or one cfs. The 325 miner's inches used by the Cameron Springs property is equivalent to a flow of 3,650 gpm. This water was used typically between the first part of May and the middle of July although usage was based on crop requirements and subject to water availability.

It typically takes an annual application of just under 19" of irrigation water to grow a hay crop in the Belgrade area. The volume of irrigation water used to grow hay on the Cameron Springs parcel is typically about 82 million gallons per growing season. About 45 percent of this amount or 37 million gallons is estimated to be lost due to evapotranspiration.

Future Water Usage

As the Cameron Springs project begins to build out, water usage patterns will change from agricultural to domestic usage. The net effect to the water balance is that less water will be needed for the development than what was used for agricultural uses, but the source of water will be from groundwater (wells) instead of surface water (irrigation ditches).

Cameron Springs will have 377 residential units including 60 units for senior housing. Water usage will be the combined requirements of domestic wastewater and irrigation needs for the parkland and lawn areas. Typically, lawns are watered at a rate of about one inch per week, including precipitation. There will be about 54 acres of "green" area requiring irrigation including 2.26 acres of median area, 48.7 acres of lawn area and 2.77 acres of landscaped park area.

The annual irrigation requirement is estimated to be 27.6 million gallons of water. If water usage is spread evenly through the week, the daily irrigation requirement will be 189,000 gallons. The seasonal water loss due to irrigation is estimated to be 12.4 million gallons.

Domestic water requirements are estimated by assuming the senior housing will be two bedroom units and the remaining housing three bedrooms. Two bedroom units are estimated to require 225 gallons of water per day or 13,500 gpd. The three bedroom units are estimated to each require 300 gallons per day or 95,100 gpd. Total domestic water requirements are estimated to be 108,600 gpd or 39 million gallons per year. Evaporation losses are estimated at five percent or roughly two million gallons per year. The total water required has dropped from 82 million gallons needed to grow hay to 67 million gallons per year to support the proposed development, a net reduction in water need of 15 million gallons per year.

Augmentation:

Augmentation of water losses is currently required for new municipal uses of water by DNRC. If there was a net water loss of 37 million gallons of water per year due to evapotranspiration while the property was under Ag use, and this loss drops to 14 million gallons per year due to the property being developed, should augmentation really be required?

Currently, augmentation plans require the retirement of old surface or groundwater rights to offset a perceived reduction in the amount of water available for existing water rights holders. Since Cameron Springs is estimated to need 67 million gallons of water per year, and will return at least 53 million gallons of water back to the aquifer immediately, the rough augmentation number is likely to be 14 million gallons. The retirement of the irrigation right of 82 million gallons should be more than enough to offset the estimated 14 million gallons of water lost to evapotranspiration.

DEQ Requirements:

DEQ requires a domestic water supply to be able to supply the maximum day demand with the largest well out of production. An average day of use is estimated at 108,600 gallons for domestic usage and 189,000 gallons for irrigation. Total average system need is 297,600 gpd during the growing season.

A peaking factor of 2.4 gives a peak day estimate of 714,240 gallons. This flow can be satisfied by a combination of wells flowing at a rate of 496 gpm. Assume a minimum of three wells, each flowing at 250 gpm, will be required.

DEQ also requires water storage for any public water system serving over 50 units. Water storage facilities are typically sized to accommodate the average day demand plus the fire demand which is 1,000 gpm for a two hour duration or 500 gpm if the buildings are provided with fire sprinklers. Cameron Springs is anticipated to be sprinkled so the fire demand is estimated at 60,000 gallons. The tank should hold at least 357,600 gallons and can be elevated or at grade. If the tank is not elevated, it will need to be provided with a booster station with backup power.

Wastewater Design Loading

Domestic water requirements are estimated by assuming the senior housing will be two bedroom units requiring 225 gallons or water per day or 13,500 gpd. The remaining homes are assumed to be three bedroom units requiring 300 gallons per day or 95,100 gpd. Total wastewater flows are estimated at 108,600 gpd.

Wastewater Treatment

The wastewater treatment system proposed for Cameron Springs is a Sequencing Batch Reactor, or SBR. An SBR facility was constructed for the King Arthur Trailer Court and RAE Subdivision a few years ago and has proved to be an efficient treatment system methodology that produces good quality effluent.

SBR is an activated sludge wastewater treatment process where the wastewater is treated in "batches" rather than as a flow through process as with most municipal plants. There typically is a dual train process so that one batch of wastewater "reacts" or is undergoing treatment while the other process train continues to accept flow or "fills". The main advantages of SBR technology over conventional flow through processes is that it allows greater control and "fine tuning" which provides for advanced biological nutrient removal and higher quality effluent.

Another advantage to an SBR is the facility can be sited in very small area with virtually no noise or odor, making it ideal for situations where the treatment facility is in close proximity to residential or commercial buildings.

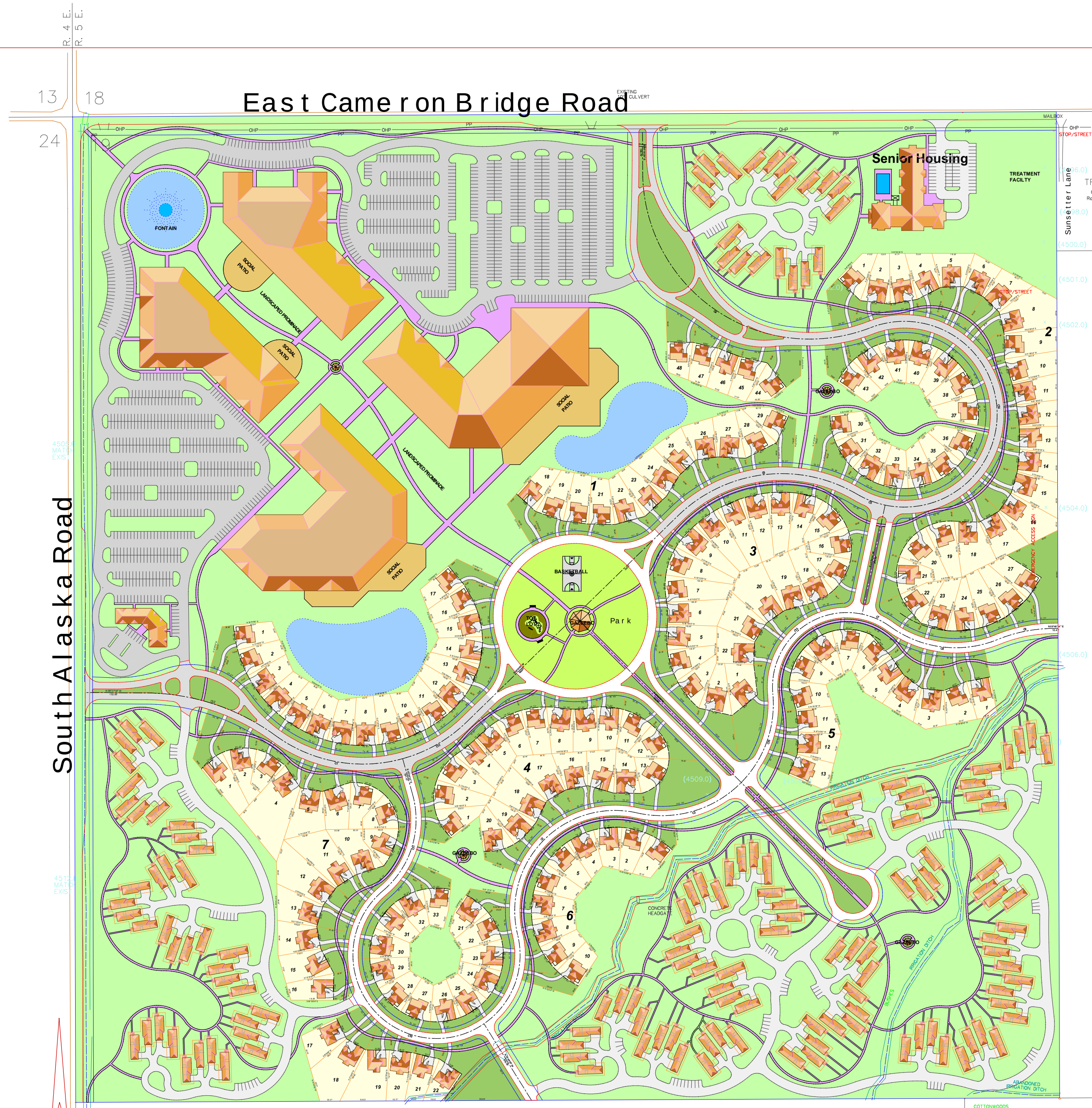
Effluent quality, measured as total nitrogen, can be as low as 3.0 mg/L if the system is operated properly. The nondegradation standard in Montana for nitrogen in groundwater after dilution is 5.0 mg/L and a well run SBR can meet this requirement at the back end of the plant.

One operator working part time can usually operate an SBR facility.

Wastewater Nondegradation

The ground water gradient in the Cameron Springs area was determined from Slagle's USGS Groundwater Study. According to this study, the groundwater gradient in this area is N 4° West at a slope of 0.008 ft/ft. The hydraulic conductivity is estimated at 120 feet per day according to a sample of area well logs. Background nitrate levels were estimated at 2.0 mg/L. The width of the drainfield perpendicular to the assumed direction of groundwater flow needs to be 1050 feet long assuming an effluent quality of 10.0 mg/L total nitrogen. As indicated above, SBR's can typically treat down to much lower nitrogen concentrations than 10 mg/L. Recent groundwater discharge permits issued by DEQ in the Four Corners area have required wastewater treatment facilities to treat effluent to 10.0 mg/L total nitrogen, so this value has been used to be conservative   The predicted downgradient concentration of nitrates at the end of a 500 foot mixing zone is 4.99 mg/L which is considered to be a nonsignificant degradation of groundwater. If the mixing zone is wider, or the SBR treats effluent to a lower total nitrogen value than 10.0 mg/L, the predicted nitrogen concentration will be less.

The nearest downgradient surface water is an un-named tributary of Thompson Spring Creek, about three miles away. The estimated time to break through assuming only four feet of coarse gravel material under the laterals is 178 years which is considered to be a non-significant degradation of groundwater.



Lot Listing:

block 1	lot 1	11528.93 sf	(0.2647 ac)
block 1	lot 2	10058.71 sf	(0.2309 ac)
block 1	lot 3	8426.10 sf	(0.1934 ac)
block 1	lot 4	8300.44 sf	(0.1906 ac)
block 1	lot 5	8624.16 sf	(0.1980 ac)
block 1	lot 6	8454.74 sf	(0.1941 ac)
block 1	lot 7	8605.87 sf	(0.1976 ac)
block 1	lot 8	9051.54 sf	(0.2078 ac)
block 1	lot 9	9041.51 sf	(0.2076 ac)
block 1	lot 10	8607.65 sf	(0.1976 ac)
block 1	lot 11	8744.49 sf	(0.2007 ac)
block 1	lot 12	9442.11 sf	(0.2168 ac)
block 1	lot 13	10941.27 sf	(0.2512 ac)
block 1	lot 14	10310.29 sf	(0.2367 ac)
block 1	lot 15	9250.91 sf	(0.2124 ac)
block 1	lot 16	10552.30 sf	(0.2422 ac)
block 1	lot 17	11490.72 sf	(0.2638 ac)
block 1	lot 18	12314.91 sf	(0.2827 ac)
block 1	lot 19	10824.48 sf	(0.2485 ac)
block 1	lot 20	9301.22 sf	(0.2135 ac)
block 1	lot 21	9536.25 sf	(0.2189 ac)
block 1	lot 22	10977.15 sf	(0.2520 ac)
block 1	lot 23	10036.81 sf	(0.2304 ac)
block 1	lot 24	11209.27 sf	(0.2573 ac)
block 1	lot 25	10353.82 sf	(0.2377 ac)
block 1	lot 26	10344.41 sf	(0.2375 ac)
block 1	lot 27	10731.26 sf	(0.2464 ac)
block 1	lot 28	10114.58 sf	(0.2322 ac)
block 1	lot 29	10809.39 sf	(0.2481 ac)
block 1	lot 30	11136.80 sf	(0.2557 ac)
block 1	lot 31	10093.60 sf	(0.2317 ac)
block 1	lot 32	8350.03 sf	(0.1917 ac)
block 1	lot 33	8344.70 sf	(0.1916 ac)
block 1	lot 34	8514.39 sf	(0.1955 ac)
block 1	lot 35	8763.92 sf	(0.2012 ac)
block 1	lot 36	8603.14 sf	(0.1975 ac)
block 1	lot 37	8597.79 sf	(0.1974 ac)
block 1	lot 38	8809.25 sf	(0.2022 ac)
block 1	lot 39	8693.71 sf	(0.1996 ac)
block 1	lot 40	8500.31 sf	(0.1951 ac)
block 1	lot 41	8416.63 sf	(0.1932 ac)
block 1	lot 42	8860.96 sf	(0.2034 ac)
block 1	lot 43	10913.11 sf	(0.2505 ac)
block 1	lot 44	12129.20 sf	(0.2784 ac)
block 1	lot 45	9108.28 sf	(0.2091 ac)
block 1	lot 46	8139.74 sf	(0.1869 ac)
block 1	lot 47	8920.86 sf	(0.2048 ac)
block 1	lot 48	11315.06 sf	(0.2598 ac)
block 2	lot 1	14186.22 sf	(0.3257 ac)
block 2	lot 2	10741.27 sf	(0.2466 ac)
block 2	lot 3	9378.94 sf	(0.2153 ac)
block 2	lot 4	11224.50 sf	(0.2577 ac)
block 2	lot 5	11657.97 sf	(0.2676 ac)
block 2	lot 6	11269.52 sf	(0.2587 ac)
block 2	lot 7	12084.09 sf	(0.2774 ac)
block 2	lot 8	17784.51 sf	(0.4083 ac)
block 2	lot 9	12256.12 sf	(0.2814 ac)
block 2	lot 10	10194.66 sf	(0.2340 ac)
block 2	lot 11	8904.31 sf	(0.2044 ac)
block 2	lot 12	8516.02 sf	(0.1955 ac)
block 2	lot 13	8930.18 sf	(0.2050 ac)
block 2	lot 14	10320.50 sf	(0.2369 ac)
block 2	lot 15	12953.96 sf	(0.2974 ac)
block 2	lot 16	15454.87 sf	(0.3548 ac)
block 2	lot 17	12694.07 sf	(0.2914 ac)
block 2	lot 18	14128.95 sf	(0.3244 ac)
block 2	lot 19	11084.92 sf	(0.2545 ac)
block 2	lot 20	13667.26 sf	(0.3138 ac)
block 2	lot 21	10482.62 sf	(0.2406 ac)
block 2	lot 22	11386.72 sf	(0.2614 ac)
block 2	lot 23	9703.26 sf	(0.2228 ac)
block 2	lot 24	9179.86 sf	(0.2107 ac)
block 2	lot 25	9818.33 sf	(0.2254 ac)
block 2	lot 26	10935.81 sf	(0.2511 ac)
block 2	lot 27	24918.61 sf	(0.5721 ac)
block 3	lot 1	20471.64 sf	(0.4700 ac)
block 3	lot 2	14104.61 sf	(0.3238 ac)
block 3	lot 3	9221.15 sf	(0.2117 ac)
block 3	lot 4	10717.63 sf	(0.2460 ac)
block 3	lot 5	9948.58 sf	(0.2284 ac)
block 3	lot 6	11004.65 sf	(0.2526 ac)
block 3	lot 7	12032.04 sf	(0.2762 ac)
block 3	lot 8	11773.72 sf	(0.2703 ac)
block 3	lot 9	10745.55 sf	(0.2467 ac)
block 3	lot 10	10747.09 sf	(0.2467 ac)
block 3	lot 11	11006.02 sf	(0.2527 ac)
block 3	lot 12	10904.42 sf	(0.2503 ac)
block 3	lot 13	10498.85 sf	(0.2410 ac)
block 3	lot 14	9864.57 sf	(0.2265 ac)
block 3	lot 15	11425.27 sf	(0.2623 ac)
block 3	lot 16	10148.57 sf	(0.2330 ac)
block 3	lot 17	10031.45 sf	(0.2303 ac)
block 3	lot 18	10668.47 sf	(0.2449 ac)
block 3	lot 19	12273.24 sf	(0.2818 ac)
block 3	lot 20	15056.42 sf	(0.3456 ac)
block 3	lot 21	11802.58 sf	(0.2710 ac)
block 3	lot 22	10158.96 sf	(0.2332 ac)
block 4	lot 1	10413.17 sf	(0.2391 ac)
block 4	lot 2	10943.69 sf	(0.2512 ac)
block 4	lot 3	11506.36 sf	(0.2641 ac)
block 4	lot 4	9626.07 sf	(0.2210 ac)
block 4	lot 5	8379.94 sf	(0.1924 ac)
block 4	lot 6	9782.83 sf	(0.2246 ac)
block 4	lot 7	10150.62 sf	(0.2330 ac)
block 4	lot 8	9392.35 sf	(0.2156 ac)
block 4	lot 9	8842.61 sf	(0.2030 ac)
block 4	lot 10	9048.58 sf	(0.2077 ac)
block 4	lot 11	9124.08 sf	(0.2095 ac)
block 4	lot 12	10372.55 sf	(0.2381 ac)
block 4	lot 13	23339.67 sf	(0.5358 ac)
block 4	lot 14	8462.48 sf	(0.1943 ac)
block 4	lot 15	10271.06 sf	(0.2358 ac)
block 4	lot 16	10137.92 sf	(0.2327 ac)
block 4	lot 17	13651.00 sf	(0.3134 ac)
block 4	lot 18	13209.83 sf	(0.3033 ac)
block 4	lot 19	9361.74 sf	(0.2149 ac)
block 4	lot 20	10703.38 sf	(0.2457 ac)
block 4	lot 21	10060.96 sf	(0.2310 ac)
block 4	lot 22	9058.36 sf	(0.2080 ac)
block 4	lot 23	8472.55 sf	(0.1945 ac)
block 4	lot 24	8358.96 sf	(0.1919 ac)
block 4	lot 25	8298.28 sf	(0.1905 ac)
block 4	lot 26	8076.28 sf	(0.1854 ac)
block 4	lot 27	8019.81 sf	(0.1841 ac)
block 4	lot 28	8098.54 sf	(0.1859 ac)
block 4	lot 29	8111.41 sf	(0.1862 ac)
block 4	lot 30	8154.68 sf	(0.1872 ac)
block 4	lot 31	8130.55 sf	(0.1867 ac)
block 4	lot 32	9047.63 sf	(0.2077 ac)
block 4	lot 33	10468.52 sf	(0.2403 ac)
block 5	lot 1	10742.16 sf	(0.2466 ac)
block 5	lot 2	11849.11 sf	(0.2720 ac)
block 5	lot 3	11782.50 sf	(0.2705 ac)
block 5	lot 4	10965.14 sf	(0.2517 ac)
block 5	lot 5	11294.16 sf	(0.2593 ac)
block 5	lot 6	9208.53 sf	(0.2114 ac)
block 5	lot 7	8728.13 sf	(0.2004 ac)
block 5	lot 8	8759.77 sf	(0.2011 ac)
block 5	lot 9	8630.37 sf	(0.1981 ac)
block 5	lot 10	9099.06 sf	(0.2089 ac)
block 5	lot 11	9686.78 sf	(0.2224 ac)
block 5	lot 12	10628.86 sf	(0.2440 ac)
block 5	lot 13	10779.63 sf	(0.2475 ac)
block 6	lot 1	9415.74 sf	(0.2162 ac)
block 6	lot 2	8596.41 sf	(0.1973 ac)
block 6	lot 3	8158.17 sf	(0.1873 ac)
block 6	lot 4	8288.11 sf	(0.1903 ac)
block 6	lot 5	8674.97 sf	(0.1991 ac)
block 6	lot 6	8528.99 sf	(0.1958 ac)
block 6	lot 7	8436.25 sf	(0.1937 ac)
block 6	lot 8	8586.58 sf	(0.1971 ac)
block 6	lot 9	9868.55 sf	(0.2266 ac)
block 6	lot 10	11523.31 sf	(0.2645 ac)
block 7	lot 1	16152.03 sf	(0.3708 ac)
block 7	lot 2	13706.68 sf	(0.3147 ac)
block 7	lot 3	8195.66 sf	(0.1881 ac)
block 7	lot 4	22870.56 sf	(0.5250 ac)
block 7	lot 5	13162.37 sf	(0.3022 ac)
block 7	lot 6	10945.44 sf	(0.2513 ac)
block 7	lot 7	11174.78 sf	(0.2565 ac)
block 7	lot 8	10005.48 sf	(0.2297 ac)
block 7	lot 9	8594.44 sf	(0.1973 ac)
block 7	lot 10	13052.02 sf	(0.2996 ac)
block 7	lot 11	16924.63 sf	(0.3885 ac)
block 7	lot 12	17968.58 sf	(0.4125 ac)
block 7	lot 13	13228.37 sf	(0.3037 ac)
block 7	lot 14	11907.04 sf	(0.2733 ac)
block 7	lot 15	12523.67 sf	(0.2875 ac)
block 7	lot 16	9888.54 sf	(0.2270 ac)
block 7	lot 17	12384.46 sf	(0.2843 ac)
block 7	lot 18	17615.39 sf	(0.4044 ac)
block 7	lot 19	15622.05 sf	(0.3586 ac)
block 7	lot 20	9757.86 sf	(0.2240 ac)
block 7	lot 21	9180.11 sf	(0.2107 ac)
block 7	lot 22	28462.47 sf	(0.6534 ac)

Legend:

Total Area of Site	161.3559 Acres
Total Residential Units	381
Total Single Family Lots	175
Average Lot Size	10,833 sq.ft.
Total Number of BayHomes	146
Total Number of Senior Housing Units	60
Total Area in Public Street	7.7986 Acres
Total Area in Assoc. Maintained Drives	6.4906 Acres
Total Area Commerical Pavement	12.2537 Acres
Total Area in Senior Housing Pavement	0.5107 Acres
Total Area in Single Family Driveways Shown	3.7366 Acres
Total Area in Walks	5.2733 Acres
Total Area of Rooftop Shown	24.8108 Acres
Total Impervious Surface	60.8743 Acres (38% Site Area)

Scale 1"=120'
June 22nd, 2006

Neighborhood Plan

Rick Harrison
Site Design Studio
www.rhsdplanning.com
8832 7th Avenue North - Golden Valley, MN 55427

Developer: Rosa Johnson Construction, LLC
1226 Stoneridge Drive - Suite C - Bozeman, MT 59719
406-556-0227

Attachment D

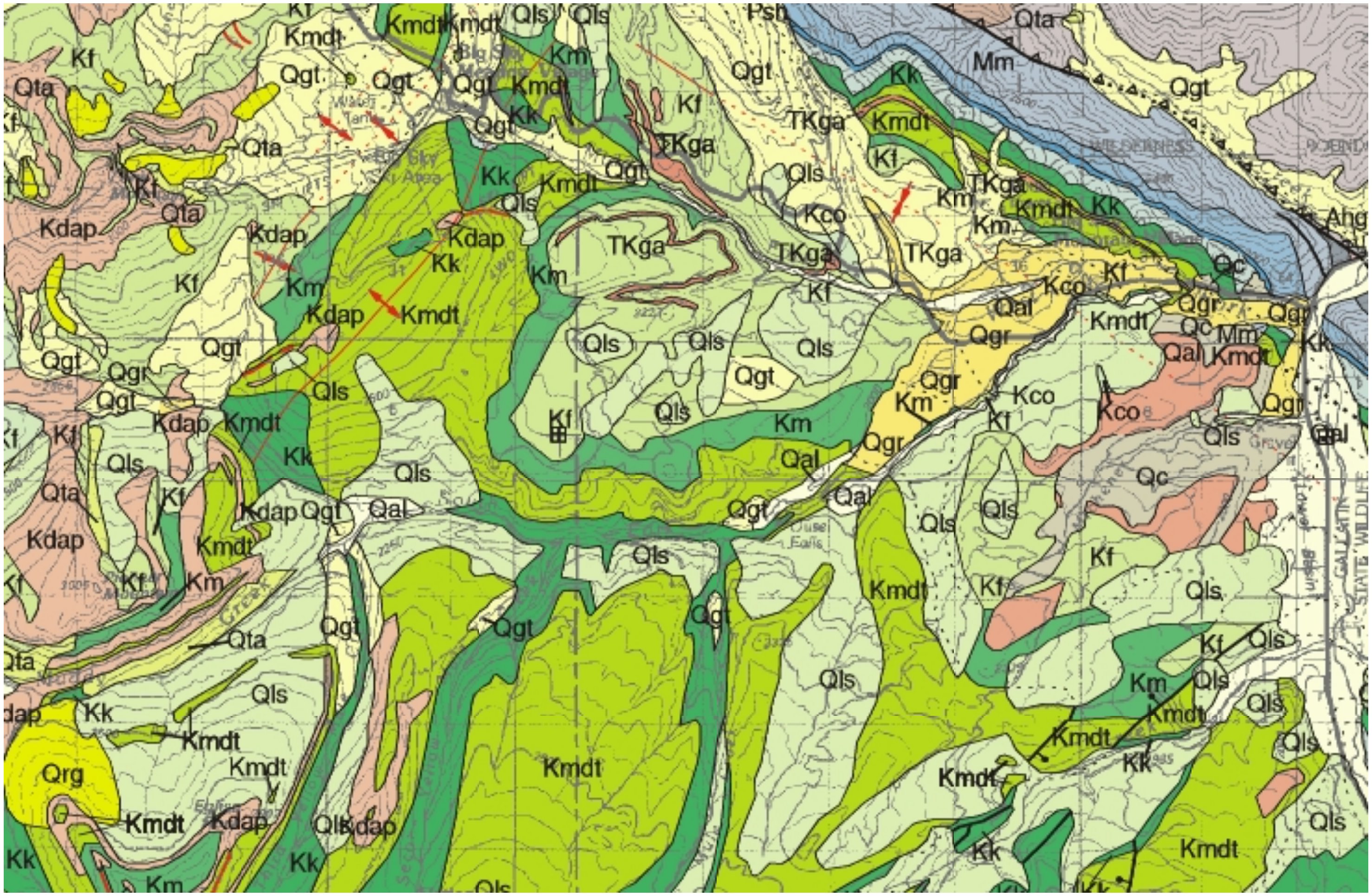
Executive Summary Gallatin Valley Water Resources Evaluation

Foreword

The following executive summary is from a report developed by Nicklin Earth & Water, Inc. (NE&W) which presents the findings of a watershed evaluation performed for the Gallatin Valley. That report was entitled:

> "Gallatin Valley Water Resources Evaluation - A Test of the Rationale of Montana Department of Natural Resources & Conservation Proposed Legislation to Amend Montana Water Law" prepared for the Doney Law Firm, Helena, Montana.

NE&W intends to release a revised/updated version of this report to the general public in approximately 30 days. This report will also include additional analysis on data available for the Gallatin Valley. It is part of on-going ground-water modeling effort being conducted by NE&W which will be used to test various conjunctive management schemes for surface water and ground water on a valley wide scale.



Attachment E. Geologic mapping in the immediate vicinity of Big Sky, Montana.
It is infeasible to model ground water for most of this area because of geologic complexity.
It is also not feasible to employ aquifer recharge for most of the project area owing to low permeability of much of the geologic strata.
However the need to do the same is questionable for most projects if a comprehensive water budget is performed and properly considered.

Attachment F

Resume - Michael E. Nicklin, PhD, PE

Resumé
Michael E. Nicklin, Ph.D., P.E.

Professional Experience Summary:

Michael Nicklin is a Registered Professional Engineer with 30 years of experience in civil engineering, hydrogeology, water resources and environmental sciences. His degrees include both geology and engineering. He specializes in using computer simulation methodologies and has developed and applied models to simulate ground water flow, surface water/ground-water interaction and water quality in streams. His modeling efforts have included water budget assessments and ground-water simulations at the water-shed scale. He has taught several collegiate courses in Engineering Mechanics at Montana State University and undergraduate/ graduate level courses in Fluid Mechanics, Hydrology, and Optimization Theory at the University of Nebraska and has guided graduate students in subjects ranging from erosion and sediment transport through ground-water modeling. He has extensive field experience including: surface water quality/sediment sampling/measurement; drilling and logging test borings in soil and ground-water systems; designing and completing observation/water supply wells; conducting pumping tests and slug tests for monitoring and well networks; utilization of geophysical methodology; and sampling for soil and ground-water contamination at a variety of sites from gasoline service stations to large National Priority Listing (NPL) sites. He has conducted feasibility studies for sites requiring ground-water treatment and soil remediation. He has been involved in addressing water management issues related to Coal Bed Methane (CBM) production and coal-mining activity. He has provided expert witness support services for several different legal entities in areas ranging from water rights, surface water, ground water to environmental contamination issues. Michael founded Nicklin Earth & Water, Inc. in 1995, a firm which specializes in providing water resources services and in solving complex water resource and environmental problems.

Selected/Representative Recent Project Experience (since 1991):

- **Expert Witness, Mitchell Slough, Hamilton, Montana.** Michael provided expert witness services to the Doney, Crowley, Bloomquist & Uda, Helena, Montana and testified as to the nature of surface water and ground-water interaction in a section of the Bitterroot valley north of Hamilton.

- **Expert Witness, Pinnacle Energy, Inc., Sheridan, Montana.** Michael is currently providing expert witness services to the Crowley Law Firm, Billings, Montana in addressing water related issues from coal bed methane production in Montana on behalf of Pinnacle Energy.

- **Expert Witness, Texaco Sunburst Site, Sunburst, Montana.** Michael provided expert witness services to the Lewis, Slovak & Kovacich, P.C. of Great Falls, Montana involving issues related to a historic gasoline spill beneath the City of Sunburst.

- **Expert Witness, Water Rights Case in the Upper Clark Fork River, Warm Springs, Montana.** Michael has provided expert witness services to three different law firms involving water rights disputes in the Upper Clark Fork River. The law firms include the following:

  Moore, O'Connell & Refling P.C., Bozeman, Montana
  Doney, Crowley, Bloomquist & Uda, Helena, Montana
  Jardine, Stephenson, Blewett & Weaver, P.C., Great Falls, Montana

- **Expert Witness, Water Rights Case, Clyde Park, Montana.** Michael provided expert witness services to Landoe, Brown, Planalp, Braaksma & Reida, P.C. regarding a water rights dispute involving spring water emanating from a shallow aquifer.

- **Expert Witness, Environmental Case, Bull Lake, Northwestern Montana.** Michael provided expert witness and courtroom testimony services for Poore, Roth & Robinson, P.C. involving sediment transport issues.

- **Expert Witness, Bozeman Solvent Site.** Michael provided expert witness services on behalf of attorneys representing the Hartford Insurance Group related to this project.

- **Expert Witness, Lockwood Solvents Site.** Michael provided expert witness services to the following two law firms involving this chlorinated solvents plume:

  Moore, O'Connell & Refling P.C., Bozeman, Montana
  Beck Richardson & Amsden PLLC, Bozeman, Montana

- **Expert Witness, Environmental Case, Colstrip, Montana.** Michael is providing expert witness services to Beck Richardson & Amsden on this project which involves providing testimony regarding ground-water mounding associated with a reservoir system.

- **Bozeman Solvent Site Remedial Investigation/Feasibility Study, Bozeman, Montana**. Michael has acted as both the Project Manager and Technical Manager for this Montana Superfund site. He represents the City of Bozeman which was named as one of the Primary Responsible Parties (PRPs). The Bozeman Solvent Site relates to a former dry cleaner spilling perchloroethylene (PCE) into the sewer infrastructure which in turn leaked to soil and ground water. Michael has led the remedial investigation, interim remediation efforts, developed a conjunctive surface water/ground-water fate-and-transport model, and has provided expert testimony/litigation support on behalf of the City of Bozeman (City).

- **Upper Teton Basin Recharge Demonstration Test, Driggs/Victor, Idaho for Friends of the Teton River.** Ground-water hydraulics specialist responsible for assisting Friends of the Teton River in conducting an irrigation recharge demonstration test. The project effort includes collecting ground-water level data, completing site-specific recharge demonstration tests, and modeling the conjunctive surface water/ground-water system.

- **Ground-water Modeling Services for Water Management Program in Pumpkin Creek Drainage, Wyoming for Barrett Resources.** Performed ground-water modeling services under subcontract to predict ground-water discharges from coal bed methane extraction in a thick coal seam.

- **Utility Solutions/Ground-water Modeling Studies, Bozeman, Montana.** Michael is conducting ground-water modeling efforts to address surface water/ground-water interaction issues along the W. Gallatin River near an area undergoing development. Three different ground-water models were developed to address a variety of issues ranging from ground-water quality to water quantity.

- **Valley Garden Golf Village, Ennis, Montana.** Project hydrogeologist/engineer responsible for evaluating and addressing water supply issues for this existing subdivision.

- **Ground-water/Water Rights Services for Ramshorn Ranch, LLC - McAllister, Montana.** Water resources specialist responsible for evaluating the significance of ground-water/surface water interaction for a ranching entity's water rights application near South Meadow Creek.

- **Ground-water Services for Manley Meadows - Bozeman, Montana**. Water resources specialist responsible for evaluating the significance of ground-water resource utilization associated with this proposed subdivision.

- **Specialized Ground-water/Surface Water Services to Morrison-Maierle Consultants.**

Michael is providing a range of expertise under subcontract to Morrison-Maierle for a broad range of projects including conducting both ground-water modeling and surface water modeling.

- **Ground-water Services for Pronghorn Meadows Subdivision, Ennis, Montana.** Project hydrogeologist responsible for evaluating and addressing ground-water resource and water quality issues for this proposed subdivision.

- **Ground-water Services for Green Hills Ranch Subdivision - Bozeman, Montana.** Project hydrogeologist responsible for evaluating and addressing ground-water resource and water quality issues for this proposed subdivision.

- **Ground-water Services - Big Hole River Ranch near Divide, Montana**. Provided hydrogeologic/water resource services as a sub-consultant for a planned development along the Big Hole River in Southwestern Montana.

- **Ground-water Services - Whitehall Development Corporation - Whitehall, Montana.** Project hydrogeologist responsible for evaluating and addressing ground-water resource issues for a proposed industrial park.

- **Turner Enterprises, Inc., Gallatin Gateway, Montana.** Developed two separate ground-water models to evaluate inter-relationships between surface water/ground water at the Flying D Ranch.

- **Ground-water Modeling Services for Water Management Program in Pumpkin Creek Drainage, Wyoming for Barrett Resources.** Performed ground-water modeling services under subcontract to predict ground-water discharges from coal bed methane extraction in a thick coal seam.

- **Upper Teton Basin Ground-water Model, Teton County, Driggs, Idaho.** Ground-water hydraulics specialist responsible for developing and applying a three-dimensional model for predicting the changes in ground-water system response to drought and transitions in ground-water and surface water utilization in the Upper Teton Basin.

- **Absaloka Mine, Westmoreland Resources, Hardin, Montana.** Ground-water hydraulics specialist responsible for developing and applying a three-dimensional model for predicting the ground-water system response associated with planned future coal mining activity.

- **Spring Creek Mine, Kennecott Energy (Rio Tinto Ltd), Decker, Montana.** Ground-water hydraulics specialist responsible for developing and applying a three-dimensional model for predicting the ground-water system response associated with planned future coal mining activity.

- **Area C Ground-water Model, Western Energy Company, Colstrip, Montana.** Ground-water hydraulics specialist responsible for developing and applying a three-dimensional model for predicting the ground-water system response associated with planned future coal mining activity.

- **Area D Ground-water Model, Western Energy Company, Colstrip, Montana.** Ground-water hydraulics specialist responsible for developing and applying a three-dimensional model for predicting the ground-water system response, and the impact on springs associated with planned future coal mining activity.

- **Warm Springs Ponds Operable Unit, Warm Springs, Montana for ARCO.** Ground-water hydraulics specialist responsible for developing and applying a three-dimensional interactive surface/ground-water model for remedial design purposes.

- **Lower Area One Operable Unit, Butte, Montana for ARCO**. Ground-water hydraulics specialist responsible for developing and applying a three-dimensional interactive surface/ground-water model for remedial design.

- **Harlowton Milwaukee Roundhouse Site for City of Harlowton, Montana.** Provided technical assistance with respect to soil/ground-water contamination issues on property owned by the City of Harlowton at the former Milwaukee Railroad Roundhouse.

- **Surface Water Evaluation - South Fork of West Fork Gallatin River, Big Sky, Montana.** Project Manager responsible for surface water monitoring program to collect baseline data on surface water flows, nutrients and periphyton.

- **Spotted Horse Creek, LX Bar Creek Water Management Planning for Energy Consortium, Gillette, Wyoming.** Project Engineer/Scientist responsible for a preliminary feasibility study dealing with managing production water derived during the coal bed methane extraction process.

- **Twin Cities Army Ammunition Plant (TCAAP), Arden Hills, Minnesota.** Assistant Project Manager responsible for Remedial Investigations and a Feasibility Study being conducted on behalf of the U.S. Army to address soil and ground water impacted by chlorinated solvents.

- **Erosion Control/Sediment Yield Studies - Big Sky, Montana**. Project Manager responsible for assisting a large development in quantifying potential erosion/sediment yields associated with construction activities. This effort included field investigations, sediment sampling, and utilization of sediment yield models such as WEPP and SEDCAD.

- **Rice Creek Watershed District, Arden Hills, Minnesota.** Responsible for developing a ground-water model to assess the capability of the aquifer formation to receive treated water from a large pump-and-treat remediation program at a site impacted by chlorinated solvents.

- **E.I. duPont de Nemours Textile Factory, Old Hickory, Tennessee.** Project Engineer/Scientist responsible for leading a large preliminary environmental site assessment to address the hydrogeology and potential volatile, semi-volatile organics and metals contamination of soil and ground water using cone-penetrometer methods.

- **Campbell Soup Company, Worthington, Minnesota.** Project Manager who lead environmental assessment, investigations and clean-up activity involving soil and ground water impacted by fuel spills.

- **Surface Water Quality Assessment/Modeling - Gallatin River, Four Corners Area, Montana.** Oversaw a surface water quality/modeling effort to address DEQ narrative standard requirements for planned commercial/housing development activities near Four Corners area. The effort is being conducted for the following developments:

  Zoot Enterprises
  Four Corners for PC Development.

- **Surface Water Quality Assessment/Modeling - West Fork Gallatin River, Big Sky, Montana.** Project Manager responsible for a surface water modeling effort to address Montana Department of Environmental Quality (DEQ) narrative standard requirements for planned housing development activities in the Big Sky area. This project included assembling relevant available background water quality data, developing a conceptual model, estimating surface water flows, constructing a water quality model for predicting the relative impacts of nutrient loading on algae growth in the West Fork of the Gallatin River. The model has been applied to the following Big Sky vicinity developments:

Yellowstone Mountain Club
Spanish Peaks Subdivision
Antler Ridge Subdivision
Sleeping Bear Subdivision
Locati Subdivision
Firelight Meadows Subdivision

Professional Experience:

Principal (Owner), Nicklin Earth & Water, Inc., Bozeman, Montana 1995 - present.
Technical Manager, Canonie Environmental, Bozeman, Montana, 1994-1995.
Supervising Engineer, ESA Consultants, Bozeman, Montana, 1992-1994.
Principal Engineer, James M. Montgomery (now Montgomery-Watson), 1987-1992.
Assistant Professor, Civil Engineering, University of Nebraska-Lincoln, 1983-1987.
Instructor/Research Assistant, Montana State University, Bozeman, 1978-1983.
Hydrogeologist, Montana Bureau of Mines and Geology, 1976-1978.
Geophysicist, Texaco, Inc., Houston. Texas, 1974-1976.
Graduate Research Assistant, Earth Science, Iowa State University, 1972-1974.

Education:

Ph.D., C.E., Montana State University, 1983
M.S., Water Resources, Iowa State University, 1974
B.S., Civil Engineering, Montana State University, 1979
B.S., Geology, Iowa State University, 1972

Registration:

Professional Engineer, Montana (7842PE), Minnesota (21663)
Nebraska (E-6423) [Emeritus]

Affiliations:

Chi Epsilon Civil Engineering Honorary
Sigma Xi (Research Honorary)
American Society of Civil Engineers
Association of Ground Water Scientists and Engineers

Awards:

Outstanding Performance Award for Years 1988-1989, James M. Montgomery (now Montgomery-Watson).
Outstanding Technical Contribution, 1995, Smith Environmental (formerly Canonie Environmental).

Publications/Papers:

Nicklin, M.E. “Model simulations of hydrologic responses at coal mines and projection of ground-water discharge rates in coal-bed methane settings.” Presented at the 2006 Billings Land Reclamation Symposium, Billings, Montana.

Nicklin, M.E. & Liebelt, G. “Utilization of a regional ground-water model to predict relative impacts of life of mine plans for Area C near Colstrip, Montana.” 2000 Billings Land Reclamation Symposium, Billings, Montana.

Nicklin, M.E., “Bozeman Solvent Site”, Water for the New Millenium, American Water Resources Association, Great Falls, Montana. October, 2000.

Nicklin, M.E., J. Kelly, J. Mitchell. “Field and analytical tools to manage conflicting objectives”, North Central Section - Geological Society of America, 1991, Toledo, Ohio.

Nicklin, M.E. & Woldt, W.E. “Identification of a management strategy for a conjunctive surface-groundwater system using optimization.” by Nebraska Water Resources Center, Conservation and Survey Division, University of Nebraska-Lincoln for U.S. Geology Survey, August, 1987.

Nicklin, M.E., J.I. Remus, and J. Conroy, “Gully bank erosion of loessial soil in urbanizing watersheds.” International Symposium on Drainage Basin Sediment Delivery, Albuquerque, New Mexico, 1986.

Nicklin, M.E., “Time series analysis of irrigation return flow”, Ph.D. Thesis, Montana State University, 1983.